RETINOSCOPY

THORINGTON

FIFTH EDITION

RETINOSCOPY
(SHADOW TEST)

THORINGTON

Reviews of Previous Editions of

Thorington's Retinoscopy.

From "The Medical Record," New York.

"This little manual deserves a second edition, and will undoubtedly pass through many more. It presents a clear, terse, and thorough exposition of an objective method of determining refraction errors which is deservedly increasing in popularity. In our opinion the author is amply justified in declaring that its great value in nystagmus, young children, amblyopia, aphakia, and in examining illiterates and the feeble-minded cannot be overestimated, and we agree with him in reminding those who attempt retinoscopy, fail, and ridicule it, that the fault is behind and not in front of the mirror. The book is well printed and usefully illustrated."

From "The Annals of Ophthalmology," St. Louis, Mo.

"Retinoscopy has come to stay. It is not a fad, neither a fashion. It is scientific, and withal so eminently practical in its application as to commend it to every thinking worker in ophthalmology. The tendency in the medicine of to-day is toward objective methods. An objective method must possess two attributes: exactness and absolute independence of the patient's testimony. In addition to these qualities, an objective method must, if it is to meet with general acceptance, be easy of application. Ophthalmoscopy and ophthalmometry are but relatively exact in refractive work, seeing which the trial-case has held its supremacy up to date; nor would we wish to relegate it to the background. With a patient whose testimony is trustworthy exact results are thus obtainable, but it requires the most intelligent cooperation on the part of the examined. If, however, there be but the least departure from the conditions essential to close work with the test-lenses—as, for instance, with foreigners, illiterates, children, partial amblyopics, or mental astigmatics—retinoscopy stands ready to furnish a verdict from which there can be no appeal, when one has learned to properly interpret the movements observed in the pupillary area. It is to the elucidation of these latter movements as observed through a plane mirror at a distance of one meter that Dr. Thorington devotes himself in the volume before us. The treatment of the subject is so beautifully simple that one who runs may read."

From "The Journal of the American Medical Association," Chicago, Ill.

"The author of this well-written little book has very satisfactorily described the most approved methods of retinoscopy. The work is especially valuable in that for a great part it details the results of personal investigation of so well-known an authority on this subject as Dr. Thorington. Oculists accustomed to casually use retinoscopy as practised in the old way, with the concave mirror or with the ophthalmoscopic mirror, will be surprised to note the marked evolution of the modus operandi of this test as developed by Drs. Jackson and Thorington. With perfected instruments and strict attention to arrangement of light, distance, and other details, a surprising degree of proficiency and accuracy is possible. Any one pursuing the modern methods of retinoscopy will soon be convinced of its superiority over all other objective tests, and every worker in ophthalmology realizes the necessity of at least one reliable objective method of refraction."

From "The New Orleans Medical and Surgical Journal," New Orleans, La.

"We have nothing but a good word for this little book. It seems to fulfil well the purpose intended. It gives a brief, clear description of the means and manner of retinoscopy, together with the principles or natural laws upon which it is founded. The author has done well in selecting the method he thinks best and simplest, and has confined himself to it, so that the student will have no difficulty or confusion in following the manual step by step, and learning to put in practice for himself what is described in the pages. This once accomplished, he can readily, if he becomes convinced of its usefulness, acquire the variations and refinement upon this mode of examination."

From "The New York Medical Journal," New York.

"This little book presents as simple and practical a description of the shadow test as exists in our language."

From "The Scottish Medical and Surgical Journal," Edinburgh, Scotland.

"Dr. Thorington's lucid text is accompanied by twenty-four good illustrations, and on every page one notes that careful attention has been paid to little details of manipulation which stamp the writer as a practical teacher."

From "The Homeopathic Eye, Ear, and Throat Journal," New York.

"A practical and useful book. This is one of the most concise and clearest explanations of this subject we have seen. Retinoscopy is one of the most valuable aids we have in refractive work."

From "The Denver Medical Times," Denver, Col.

"His directions and descriptions are exceptionally clear and concise, and the little book he has written, we think, will be helpful to every physician who is interested in the fitting of glasses."

From "The Chicago Medical Record," Chicago, Ill.

"This little book is the most practical and complete exposition of the value and application of the shadow test in determining refractive errors with which we have any acquaintance. The illustrations, directions, advice, and general information in the book are all admirable."

From "The Post-Graduate," New York.

"This work on retinoscopy is divided into six chapters and an index. As stated in the preface, it is an abstract of the author's previous writings and lectures on retinoscopy, delivered at the Philadelphia Polyclinic. It is intended for college students and post-graduates, yet it is sufficiently complete for the use of the ophthalmologist. Retinoscopy has been selected as the name of the test, as it is the retina in its relative position to the refractive media which is studied. Skiascopy and skiagraphy are therefore regarded as misleading. To all those who are interested in this test for the determination of refraction we commend the work."

From "The Philadelphia Polyclinic," Philadelphia.

"We take pleasure in commending this concise statement of the methods to be employed in the routine use of a most valuable objective means of determining the errors of refraction. The student is told in simple English how to proceed in the examination."

From "The Boston Medical and Surgical Journal," Boston, Mass.

"This little manual is certainly the clearest exposition of this method of estimating refraction of the eye that has yet been published. The methods described are not so complicated as those taught in some other handbooks. The text is clear, and the illustrations serve the purpose for which they are designed admirably. Taken altogether, it is the most practicable handbook on retinoscopy yet published."

From "The Journal of Ophthalmology, Otology, and Laryngology," New York.

"We most emphatically recommend this little book to the beginner in the study of this method of determining refraction. The title is an index of the character of the text. It is positive, exact, practical. The aim of the author has been to present facts, and in as small space as possible. He has succeeded absolutely. The average work on this subject is, to the beginner, somewhat confusing, from the amount of theory presented—theory which is not always clear to the student. This has been avoided in the present case. Little, if any, theory is included, and the monograph is a series of categorical statements—clear, precise, and sufficient."

BY THE SAME AUTHOR

RETINOSCOPY

(OR SHADOW TEST)

IN THE

DETERMINATION OF REFRACTION AT ONE METER DISTANCE, WITH THE PLANE MIRROR

BY

JAMES THORINGTON, A.M., M.D.

AUTHOR OF "REFRACTION AND HOW TO REFRACT"; "THE OPHTHALMOSCOPE AND HOW TO USE IT"; PROFESSOR OF DISEASES OF THE EYE IN THE PHILADELPHIA POLYCLINIC AND COLLEGE FOR GRADUATES IN MEDICINE; OPHTHALMOLOGIST TO THE ELWYN AND VINELAND TRAINING SCHOOLS FOR FEEBLE-MINDED CHILDREN.

FIFTH EDITION, REVISED AND ENLARGED

FIFTY-FOUR ILLUSTRATIONS
TEN OF WHICH ARE COLORED

LONDON
REBMAN, LIMITED
129, SHAFTESBURY AVENUE, W. C.
1906

THIS BOOK IS AFFECTIONATELY DEDICATED TO THE MEMORY OF

FELIX A. BETTELHEIM, PH.D., M.D.,

MY FRIEND AND ASSOCIATE DURING HIS SIX YEARS' RESIDENCE, AS SURGEON OF THE PANAMA RAILROAD COMPANY, AT PANAMA.

PREFACE TO THE FIFTH EDITION.

In preparing the fifth edition of Retinoscopy for publication, the writer has made every effort to make the book more worthy of the favor with which it has been received in this country and abroad. Although but a short time has elapsed since the last large edition was brought out, every page has been carefully revised and new instruments, including the Electric Retinoscope, illustrations and descriptions have been incorporated to bring the work up to date.

120 S. Eighteenth St., Philadelphia,
September, 1906.

PREFACE TO THE FIRST EDITION.

At the earnest solicitation of many students and friends, this book is presented as an abstract of the author's previous writings and lectures on Retinoscopy, delivered during the winter course on Ophthalmology, at the Philadelphia Polyclinic.

In presenting a manual of this kind the writer does not presume to detract from the writings or teachings of others, or the excellent work on Skiascopy, by his friend and colleague, Dr. E. Jackson; but wishes to elucidate in as concise a manner and few words as possible the method of applying retinoscopy, which has given most satisfaction at his hands.

While intended for college students and post-graduates, yet there is ample material given whereby the ophthalmologist at a distance may acquire a working knowledge of the method, by study and practice in his office.

For three reasons Retinoscopy, in preference to Skiascopy, has been chosen as the title:

First, that it may not be confounded with Skiagraphy.

Second, that it is the name by which the test is universally known; and —

Third, that it is the retina in its relative position to the dioptric media which we study.

120 S. EIGHTEENTH ST., PHILADELPHIA,
March, 1897.

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RETINOSCOPY.

CHAPTER I.

DEFINITION.—NAMES.—PRINCIPLE AND VALUE OF RETINOSCOPY.—SUGGESTIONS TO THE BEGINNER.

Definition.—Retinoscopy (see preface to the first edition) may be defined as the method of estimating the refraction of an eye by reflecting into it rays of light from a plane or concave mirror, and observing the movement which the retinal illumination makes by rotating the mirror.

Names.—Shadow test, diptroscopy, fundus-reflex test, keratoscopy, fantoscopy, pupilloscopy, retinophotoscopy, retinoskiascopy, skiascopy, umbrascopy, koroscopy, etc., are some of the other names given to this method of estimating the refraction, and their number and greater or less inappropriateness have had much to do, no doubt, with keeping retinoscopy in the background of ophthalmology instead of giving it the prominence which it more justly deserved and is now receiving from ophthalmologists in all parts of the world.

The principle of retinoscopy is the finding of the point of reversal (the far-point of a myopic eye), and to do this, if an eye is not already sufficiently myopic, it will be necessary to place in front of it such a lens, or series of lenses, as will bring the emergent rays of light to a focus

at a certain definite distance (see Point of Reversal, chap. IV).

Value of Retinoscopy.—Those who would criticize retinoscopy because "we see nothing and think nothing of the condition of the fundus," base their criticism apparently on the name retinoscopy, rather than from any great amount of practical experience with the method. While admitting that the ophthalmoscope in front of a well-trained eye will often give a close refractive estimate of the eye under examination, yet only to the few does such skill obtain, and even then there is that uncertainty which does not attach itself to the retinoscope in competent hands. The ophthalmologist who knows how to use the retinoscopic mirror accurately has the advantage of his confrères who are ignorant of the test; it gives him a position decidedly independent of his patient, and puts him above the common level of the traveling "Great Doctor Eye" and "refracting optician," who are tied to the trial-lenses and the patient's uncertain answers. Furthermore, when it is remembered that from fifty to eighty per cent. of the patients consulting the ophthalmologist do so for an error of refraction, it is well that he be most capable in this important branch of the subject.

The wonderful advantage of retinoscopy over other methods needs no argument to uphold it; the rapidly increasing number of retinoscopists testify to its merits.

The writer, from his constant use of the mirror, would suggest the following axiom: That, *with an eye otherwise normal except for its refractive error, and being under the influence of a reliable cycloplegic, there is no more accurate objective method of obtaining its exact correction than by retinoscopy.*

Retinoscopy gives the following advantages:

The character of the refraction is quickly diagnosed.

The exact refraction is obtained without questioning the patient.

Little time is required to make the test.

No expensive apparatus is necessarily required.

Its great value can never be overestimated in cases of nystagmus, young children, amblyopia, aphakia, illiterates, and the feeble-minded.

From what has just been written, it must not be under-

FIG. 1.—THE AUTHOR'S SCHEMATIC EYE FOR STUDYING RETINOSCOPY. (*For description, see chap. vi.*)

stood that the patient's glasses are ordered immediately from the findings obtained by retinoscopy; for, on the contrary, all retinoscopic work, like ophthalmometry

in general, should, when possible, be confirmed at the trial-case.

It is only in the feeble-minded, in young children, and in cases of amblyopia that glasses are ordered direct from the findings obtained in the dark room.

The subjective method of placing lenses before the patient's eyes and letting him decide by asking "is this better?" or "is this worse?" only too often fatigues the examiner and worries the patient, giving him or her a dread or fear of inaccuracy that does not satisfy the surgeon or tend to inspire the patient. Whereas, when the neutralizing lenses found by retinoscopy are placed before the patient's eyes and he reads $\frac{6}{6}$ or $\frac{20}{20}$ or more, it is easy, if there is any doubt, to hold up a plus and a minus quarter diopter glass respectively in front of this correction, and let the patient tell at once if either glass improves or diminishes the vision.

The writer is not condemning the subjective or other methods of estimating the refraction, nor is he trying to extol too highly the shadow test, yet he would remind those who try retinoscopy, fail, and then ridicule it, that the fault with them is *back* and not in front of the mirror.

Suggestions to the Beginner.—To obtain proficiency in retinoscopy there is much to be understood. Careful attention to details *must* be given, and not a little patience possessed, as it is not a method that is acquired in a day, and it is only after weeks of constant application that accuracy is acquired. Therefore the beginner is strongly advised to learn the major points from one of the many schematic eyes in the market before attempting the human eye. At the same time he should be perfectly familiar with the laws of refraction and dioptrics, as an understanding of conjugate foci is really the underlying principle of the method—*i.e.*, a point on the retina being one focus

and the myopic or artificially-made far-point the other focus.

What is meant by major points applies more particularly to the study of the retinal illumination, its direction and apparent rate of movement, also its form, the distance between the observer and the patient, how to handle the mirror, etc., all of which are referred to under their special headings.

CHAPTER II.

RETINOSCOPE.—LIGHT.—LIGHT-SCREEN.—DARK ROOM.—SOURCE OF LIGHT AND POSITION OF MIRROR.—OBSERVER AND PATIENT. —LUMINOUS RETINOSCOPE.

The Retinoscope, or Mirror.—Two forms of the plane mirror are in use—the one large, four centimeters in diameter, with a four- or five-millimeter sight-hole often cut through the glass; and the other small, two centimeters in diameter, on a four-centimeter metal disc, with sight-hole two millimeters in diameter, *not* cut through the glass, the quicksilver or plating alone being removed. By thus leaving the glass at the sight-hole, additional reflecting surface is obtained at this point, which assists materially in exact work, as it diminishes the dark central shadow that shows so conspicuously at times, and particularly when the sight-hole is cut through the glass. The small mirror has an advantage over the large by reducing the area of reflected light, as only a one-centimeter area on each side of the sight-hole is of particular use. The small plane mirror* is the one recommended, and is made with either a straight or folding handle (see Fig. 12); the latter is for the purpose of protecting the mirror when carried in the pocket. The purpose of the metal disc on which the small mirror is secured is to keep the light out of the observer's eye, and enable him to rest the instrument

***Philadelphia Polyclinic*, November, 1893. Another form is described by Dr. E. Jackson, *American Journal of Ophthalmology*, April, 1896.

against the brow and side of the nose; but if its size should appear small, the observer can easily have a larger one made to suit his convenience. The plating or silvering on the mirror should be of the best, and free from any flaws or imperfections, for on its quality depends, in part, the good reflecting power of the mirror, which is very important.

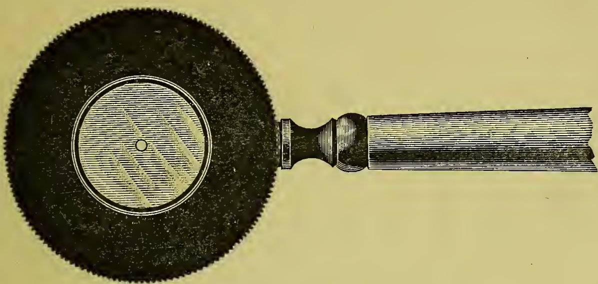

FIG. 2.—THE AUTHOR'S RETINOSCOPE.*

The central shadow just referred to as the result of the sight-hole had best be seen by the beginner by reflecting the light from the mirror onto a white surface, before he begins any study, as this dark area may annoy him later if he does not understand its origin.

The Light.—This should be steady, clear, and white. The Welsbach possesses all these qualities, but unfortunately its delicate mantle will not stand much jarring, and as a consequence, is easily broken, causing much loss of time and annoyance. The electric light made with a twisted carbon and ground-glass covering having a round center of clear glass is becoming quite popular. For constant service, however, the Argand burner is decidedly the best, when the asbestos light-screen is used to intercept the heat. Whatever light is employed, it is well to have it on an extension bracket, so that the observer may raise

*See foot-note on preceding page.

or lower it or move it toward or away from the patient, as necessary (see Fig. 3).

When gas or electric light is not at hand, a student's oil-lamp, with a suitable light-screen, will answer every purpose (see Fig. 4).

The light-screen, or cover chimney, is made of one-eight inch asbestos, and of sufficient size (six centimeters

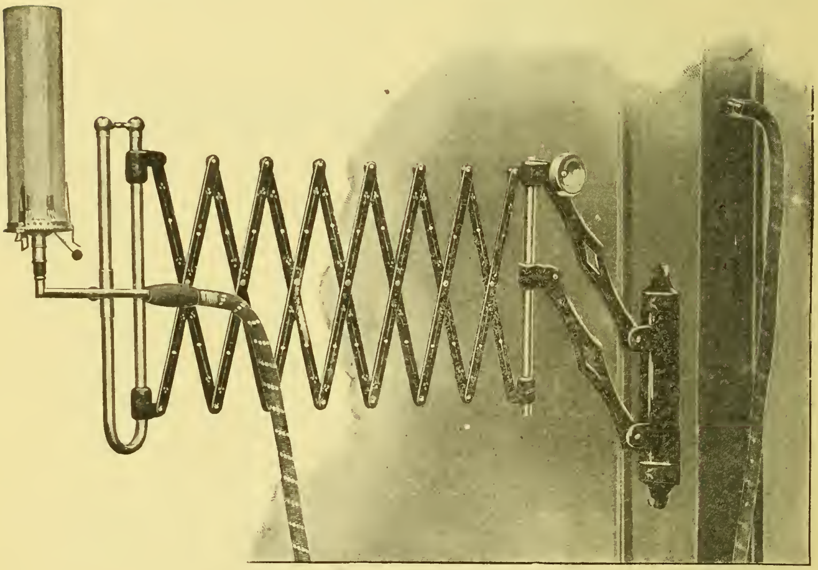

FIG. 3.

in diameter by twenty-one in height) to fit over the glass chimney of the Argand burner (see Fig. 5).

Attached to the screen are two superimposed revolving discs that furnish four round openings, respectively five, ten, twenty, and thirty millimeters, any one of which may be turned into place as occasion may require. Care should be taken that the opening used is placed opposite to the brightest, and never opposite to the edge of the blue part

of the flame. Formerly these screens were made of sheet-iron, but the asbestos has been found preferable, as it does not radiate the heat to the same extent as the iron. The purpose of the light-screen is to cover all of the flame except the portion which presents at the opening in the disc.

Ten-millimeter Opening.—This will be used in most all retinoscopic work by the beginner.

Five-millimeter Opening.—This is used to the best advantage and with no small amount of satisfaction by the expert when working close to the point of reversal.

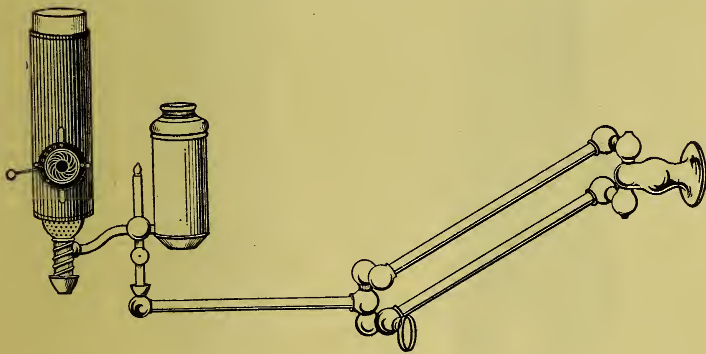

FIG. 4.

Figure 6 shows the author's new light-screen, which was described on page 1378 in the "Journal of the American Association," December 3, 1898. This is a more convenient screen for retinoscopy than the one shown in Figure 5. It is made by attaching an iris diaphragm to an asbestos chimney. The amount of light passing through the diaphragm is easily controlled by an ivory-tipped lever at the left hand side; and an index on the periphery records the diameter of the opening in use, from one to thirty millimeters.

The room must be darkened—and the darker the better; all other sources of light except the one in use should be excluded. It must not be supposed from this that the room must have its walls and ceiling blackened; on the contrary, if the shades are drawn, the room will be sufficiently dark, though of course a room with walls painted black or draped in black felt would be best, as giving a greater contrast to the condition to be studied. The exclusion of other lights, or beams of light, must be insisted upon, as the

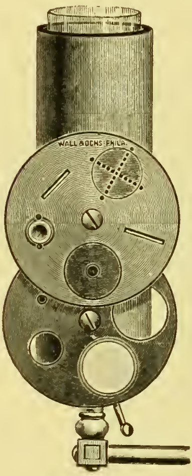

FIG. 5.—THE AUTHOR'S LIGHT-SCREEN, OR COVER CHIMNEY.
(*For a further description, see chap. vi.*)

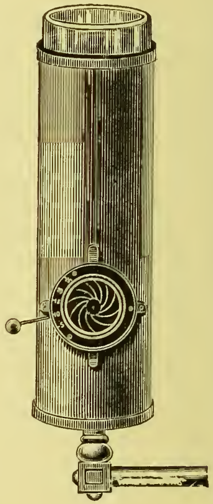

FIG. 6.—THE AUTHOR'S NEW LIGHT-SCREEN.

principal use of the darkened room is to keep all light except the light in use out of the eye to be examined, and also not to have other lights reflected from the mirror.

As the method of using the concave mirror with source of light (twenty or thirty mm. opening in screen) beyond its principal focus (usually over and beyond the patient's

head) has been superseded by the simpler and easier method of using the small plane mirror with source of light (one-half or one cm. opening in light-screen) brought as close to the mirror as possible, the description of retinoscopy which follows will refer to the latter.

The Source of Light and Position of the Mirror.—The rays of light coming out of the round opening in the light-screen should be five or six inches to the left and front of the observer, so that they may pass *in front* of the left eye and fall upon the mirror held before the right, thus leaving the observer's left eye in comparative darkness; or the observer may use the mirror before the left eye in case he is left-handed and has the light to his right. It is always best for the observer to keep both eyes wide open and to avoid having any light fall into the unused eye, which would cause him much annoyance. Some observers hold the mirror before the eye next to the screen, but this is not recommended, for the reasons just mentioned.

The observer need not make any note of his accommodation, as in using the ophthalmoscope, but, as he requires very acute vision, he should wear any necessary correcting glasses. *Any observer whose vision does not approximate* $\frac{6}{6}$ *in the eye which he uses will not get much satisfaction from retinoscopy.*

He should take his seat facing the patient, and, as the strength or brilliancy of the reflected light rapidly weakens as the distance between the mirror and the light-screen is increased, he should have the light-screen close to his face (not farther away than six inches) if he wishes to get the fullest possible strength of light on the mirror.

As the light appears just as far back in the mirror as it is in front of it, then the nearer these two objects are brought together, the more nearly do they become as one. When working close to the point of reversal, more exact work

will be accomplished if this distance between the light and mirror is very short. The nearer together the light and mirror, the brighter the retinal illumination, and greater contrast, or sharper cut edge between illumination and sur-

Fig. 7.

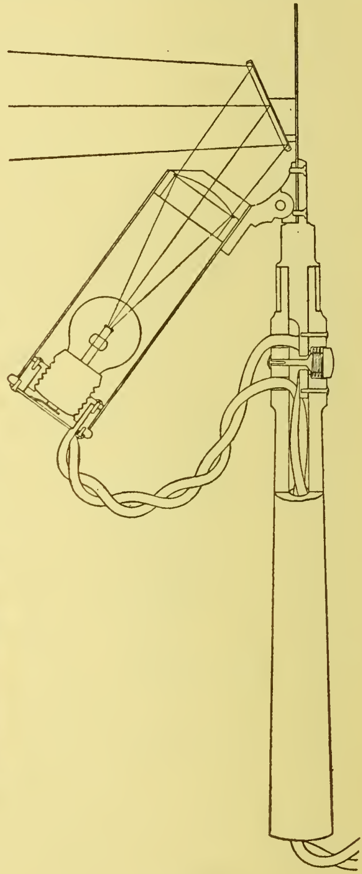

Fig. 8.

rounding shadow. The further the light from the mirror, the dimmer the retinal illumination, and there will appear, under certain conditions, a very conspicuous central shadow

as the result of the sight-hole in the mirror—*two very serious objections.*

The Luminous Retinoscope (Figs. 7 and 8).—DeZeng Patent.—The latest improvement in retinoscopes is the luminous instrument here described. This instrument is the author's plane mirror with the electric light attachment. A 5-volt electric light with tiny filament is contained in a tube placed at an angle of 45 degrees with the handle, and the mirror is correspondingly tilted to an angle of 22 degrees. The light from the filament passes divergently to a strong convex lens which renders the rays less divergent as they fall upon the mirror, and from the mirror the rays pass divergently to the patient's eye. (Fig. 8.) This instrument has innumerable points of merit: It does away with any use of gas or lamp or cover chimney; the observer is not annoyed with the heat from the gas or lamp; the observer does not have to move the light or bracket when changing from one distance to another as when working with the gas-light close to the mirror; the electric wires (cords) carrying the current to the filament are of sufficient length to give the observer two meters of space in which to practice the method; the brilliancy of the illumination can be made most intense or diminished very materially with a convenient rheostat; the size of the divergent pencil may be controlled by adjusting the condensing lens at the end of the tube. The writer is in the habit of using the mirror with the gas flame until he has obtained an approximate point of reversal and then substitutes the luminous instrument to obtain the more delicate findings; he does this for the reason that if the electric light is used for any great length of time to find the point of reversal a temporary scotoma is produced that some nervous patients occasionally object to. This luminous instrument will also bring to the notice of the

careful observer some fine changes in the lens fibers if present, that he might otherwise overlook.

The patient *must have his accommodation thoroughly relaxed with a reliable cycloplegic*, and should be seated comfortably, one meter distant, in front of the observer, with his vision steadily fixed on the observer's forehead, just above the mirror. Or, what is even better, the patient may concentrate his vision on the edge of the metal disc of the mirror or on the observer's forehead, but never directly into the mirror, as that would soon irritate and compel him to close his eye.

In this way the patient avoids the strain of looking into the bright reflexed light, and at the same time the *macular region* is refracted (see Fig. 27). It is customary to cover the patient's *other* eye while its fellow is being refracted; for obvious reasons this is specially important in cases of "squint." The axonometer placed before the eye being refracted is a decided advantage in any instance (see p. 47).

CHAPTER III.

DISTANCE OF SURGEON FROM PATIENT.—ARRANGEMENT OF PATIENT, LIGHT, AND OBSERVER.—REFLECTION FROM MIRROR.—HOW TO USE THE MIRROR.—WHAT THE OBSERVER SEES.—RETINAL ILLUMINATION.—SHADOW.—WHERE TO LOOK AND WHAT TO LOOK FOR.

Distance of Surgeon from Patient.—There is no fixed rule for this, and each surgeon may select his own distance. It might be well for the beginner to try different distances and then choose for himself. The writer prefers a one-meter distance, and with few exceptions adheres to it. Some prefer six meters, others two meters, etc. The distance of one meter has important advantages: There is no getting up or down to place lenses in front of the patient's eye, as the patient or surgeon, or both, may lean forward for this purpose, if necessary. Another advantage is that at one-meter distance there is a uniform allowance of one diopter in the estimate, which will be explained more fully under Rules for Retinoscopy at One Meter. To get the patient's eye and the observer's forehead just one meter apart, the distance may be marked off on the wall of the dark room on the side where the light is secured (see Fig. 10), or a meter stick for the purpose may be held in the hand of the observer or his assistant.

The method of obtaining the point of reversal at points other than the regulation one meter requires such an amount of extra measuring and computing that it does not meet with the general favor and satisfaction accorded

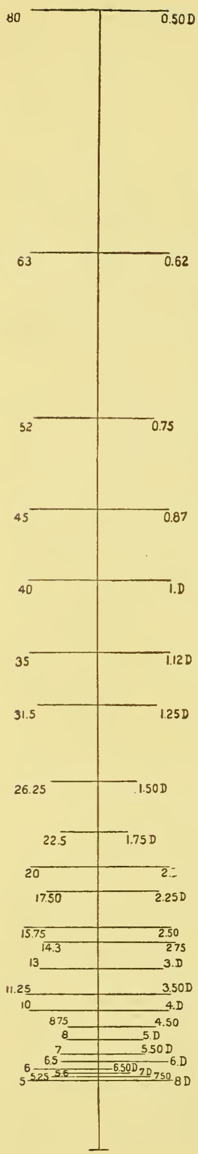

Fig. 9.—Showing Distance from Patient's Eyes in Inches and the Equivalent in Diopters.

to that found by producing an artificial myopia of one diopter. This can best be explained by reference to Figure 9, where, if the observer is at one-meter distance, and the neutralizing lens in front of the patient's eye focuses the emergent rays *about* that distance, he may have the liberty of moving forward five inches (a play of ten inches) in looking for the point of reversal, and not make a possible error in his result of more than twelve one-hundredths (0.12) of a dioptor; *whereas* if he was working closer than this, say at half a meter, and was moved forward or backward five inches to find the point of reversal, he would likely make an error of 0.5 D., or even more, if he was not extremely careful in measuring the distance at which he found the reversal point.

Arrangement of Patient, Light, and Observer.—This has already been described in great part, but reference to the accompanying sketch may give the student a more exact appreciation of the arrangement than any lengthy description could do.

For the convenience of the beginner in using the mirror, it is best, as here shown, to keep the surgeon's eye, the light, and the patient's eye on a horizontal line, and to accomplish this in children they will either have to stand,

sit on a high stool, or on the parent's lap. The beginner will find it sufficiently difficult at first to reflect and keep the light on the patient's eye with the mirror held perpendicularly, without inclining it up or down, as he would have to do if the arrangement suggested is not carried out. Placing the light to one side of the patient's head, or above it, and the observer seated at one-meter distance from the patient, is a convenient way of working retinoscopy. It has two

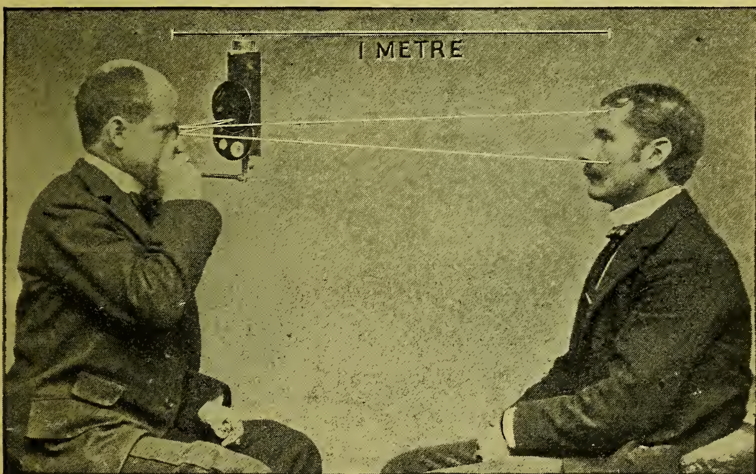

FIG. 10.—ARRANGEMENT OF PATIENT, LIGHT, AND OBSERVER.

advantages: the observer avoids the heat of the flame, and at the same time does not have to move the light. But the writer is not partial to this mode of procedure, for various reasons of precision, explained in the text. Figure 11 shows the observer's eye, one meter from the patient's eye, and the light above.

Reflection from the Mirror.—The rays of light coming from the round opening in the screen to the plane mirror are reflected divergently, as if they came from the opening

in the screen situated just as far back in the mirror as they originally started from in front (see Figs. 24, 26 and 28), and the patient, looking into the mirror, sees a round, bright spot of light, corresponding to the opening in the screen. Fig. 13.

How to Use the Mirror.—It should be held firmly before the right eye so that the sight-hole is opposite to the observer's pupil; and that it may be steady, the second phalanx of the thumb should rest on the cheek just below

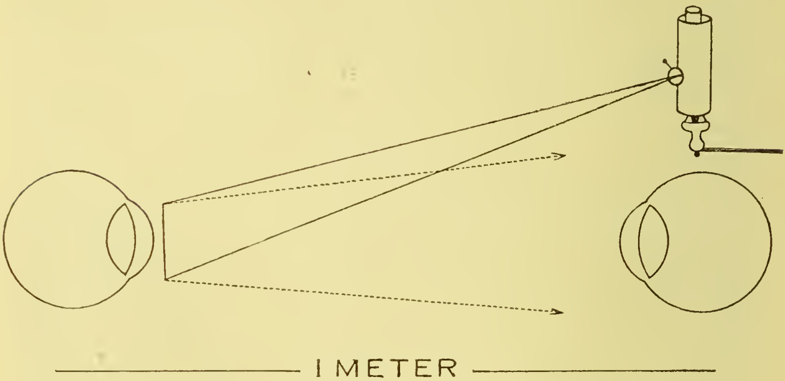

FIG. 11.—LIGHT OVER PATIENT'S HEAD AND THE OBSERVER WITH MIRROR AT ONE-METER DISTANCE.

the eye, the edge of the metal disc even touching the side of the nose if the observer's interpupillary distance is not too great. Thus held in position, its movements should be very limited, though they may be slow or quick, but *never*, at any time, should it be tilted more than one, two, or even three millimeters; for if inclined *more* than this the light is lost from the patient's eye. If the light, the patient's, and the observer's eyes are on a horizontal line, then to find the patient's eye with the reflected light all the observer has to do is to reflect the light back into the

light-screen, and by rotating the mirror to his right, carry the reflected light around on the same horizontal line until the patient's eye is reached. This may seem like a superabundance of instruction, but the finding of the patient's eye, which appears so easy, is an immense stumbling-block, at the beginning, to most students. Another

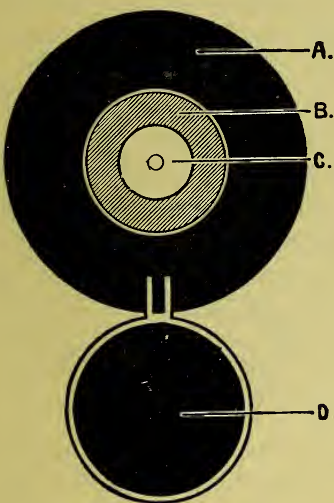

FIG. 12.

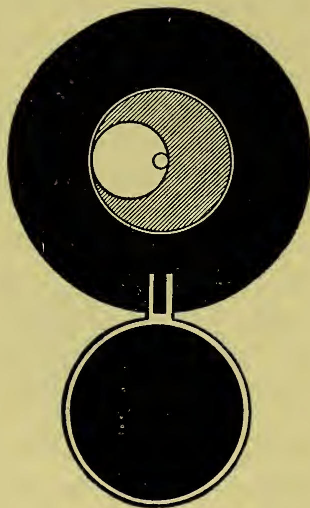

FIG. 13.

AUTHOR'S MIRROR WITH FOLDING HANDLE.

FIG. 12.—Showing central light C, on small mirror B. This is the light the patient sees when looking into the mirror, and corresponds in size to the one-centimeter opening in screen. D is the folding cap handle to protect B when not in use. A is the metal disc.

FIG. 13.—Shows the light moved to one side as a result of tilting the mirror.

way to find the eye is for the observer to hold his left hand up between his and the patient's eye and reflect the light on to it, and when this is done to drop his hand and let the light pass into the observed eye. Having succeeded in finding the patient's eye, the observer, if he is not very

careful in his limited movements of the mirror and himself, will turn the light from the eye almost before he knows it, and so be compelled to start and find it again; this causes much loss of time. A little practice on the schematic eye will assist the beginner wonderfully and give him courage, for if he hastens to the human eye, and then has to stop every minute or so to try and get the light on the eye, he soon becomes discouraged and shows his want of experience to the patient.

What the observer sees or the general appearance of the reflection from the eye.—With the mirror held before his eye, and close up to the bright light coming from the ten-millimeter opening in the light-screen, the observer will obtain a reflection from the pupillary area of the patient's eye which varies in different patients, and is subject to certain changes in the same patient as the refraction is altered by correcting lenses, or it may be changed by the turning of the patient's eye, or lengthening the distance between the mirror and the light, or increasing or diminishing the strength of the light, or increasing the distance between the observer and the patient. The reflection from the eye of the albino or blond is much brighter than from the brunette or mulatto, in whom it is not so bright, even dim. This character of the reflex is controlled, of course, in great part by the amount of pigment in the eye ground; however, in most instances, there is more or less of a yellowish-red color to the reflex, and this is especially so as the point of reversal is approached; at the point of reversal, however, the reflex becomes less brilliant and possesses something of the color of a piece of newly coined silver. Cases of high errors of refraction give a dull reflex (see Fig. 22) as compared to low errors, where the reflex is usually *very* bright (see Fig. 14). Should the media be irregular or not perfectly clear, the reflex is altered

accordingly; this will be referred to under the head of Irregular Astigmatism. The observer will also notice on the cornea and lens bright pin-point catoptric images, and at the inner edge of the iris, in many eyes, a very bright ring of light (see Fig. 14) about one millimeter in width, which is due to the very strong peripheral refraction; and as the eye is being refracted and the point of reversal approached, this peripheral ring may develop into a broader ring of aberration rays, which at times will be annoying. This will be referred to under Spheric Aberration, chapter VI.

Retinal Illumination.—By holding a strong convex lens closer to or further from a plane surface than its principal focus, or at the distance of its principal focus,

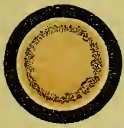

FIG. 14.

FIG. 15.

FIG. 14.—UNIFORM ILLUMINATION IN AN EMMETROPIC EYE WITH SLIGHT SPHERIC ABERRATION.

FIG. 15.—UNIFORM ILLUMINATION AS IN FIG. 10, PASSED TO THE LEFT BY ROTATING THE MIRROR, DARKNESS OR SHADOW FOLLOWING.

and letting the sun's rays pass through it, there will be seen on the plane surface a round area of light; it is this light area which corresponds to the illumination on the retina, seen in retinoscopy by reflecting the light from the mirror into the patient's eye, and hence it is spoken of as the retinal illumination, the "illuminated area," "the area of light," "the image," etc.

Of course, the form of this illumination is controlled, in great part, by the refraction of the patient's eye.

Shadow.—This is the non-illuminated portion of the

retina immediately surrounding the illumination. The retinal illumination and shadow are, therefore, in contact, and the contrast in most marked and easily recognized when the refractive error is a moderately high one, two or three diopters. It is by this combination of the illumination and non-illumination (shadow) that we study and give the "shadow test" its name. In the dark room, the patient keeping his eye fixed, the retina is stationary and in total darkness, except the portion illuminated by the light from the mirror (see Fig. 14). If the mirror be rotated the retinal illumination changes its place (see Fig. 15) and darkness, or shadow, appears in its stead. It is by this change of shadow (darkness) for illumination that we often speak of a movement of the shadow.

Where to Look and What to Look For.—With the patient, the observer, and the source of light in position as directed, the rays of light are reflected into the eye from the mirror as it is gently rotated in the various meridians, and the (1) *form*, (2) *direction, and* (3) *rate of movement* of the retinal illumination are carefully noted through a four- or five-millimeter area *at the apex of the cornea*, as *this* is the part of the refractive media in the normal eye that the patient will use *when* the effects of the cycloplegic pass away and the pupil regains its normal size.

The one- or two-millimeter area at the edge of the pupil should be avoided by the beginner, except in special instances, as only too frequently it contains a bright ring of light which may or may not give a stronger refraction than the 4-millimeter area about the apex of the cornea (see Spheric Aberration, chap. VI).

The beginner will do good work with the retinoscope if he observes closely the illumination at the center of the pupil and *avoids* looking for shadows.

CHAPTER IV.

POINT OF REVERSAL.—TO FIND THE POINT OF REVERSAL.—WHAT TO AVOID.—DIRECTION OF MOVEMENT OF RETINAL ILLUMINATION.—RATE OF MOVEMENT AND FORM OF ILLUMINATION.—RULES FOR LENSES.—MOVEMENT OF MIRROR AND APPARATUS.

Point of Reversal.—This may be defined in several ways—namely: It is the far-point of a myopic eye, or

The artificial focal point of the emergent rays of light (Fig. 25), or

The point where the emergent rays cease to converge and commence to diverge, or

The point conjugate to a point on the retina (Fig. 29), or

The point where the erect image ceases and the inverted image begins, or

The point distant from the eye under examination, where the retinal illumination can not be seen to move.

The point of magnification.

To Find the Point of Reversal.—The recognition of the point of reversal is *the principle* of retinoscopy. It is what is sought for, and, when obtained under certain definite arrangements, is the correct solution of the test. During the test it is easy to tell when the illumination moves with or opposite to the movement of the light on the face, but to get the exact point where there is no apparent movement is not always easy, and the ability to quickly find this point of reversal is only acquired after careful practice.

For example, having determined at one meter that the retinal illumination with a $+1.50$ D. in front of the observed eye just moves with the light on the face, and against with a $+1.75$ D., we know that the reversal point must be obtained with the lens numbered between the strength of these two lenses, *i.e.*, $+1.62$ D. This demonstrates how we arrive at the exact correction, and also the capability and accuracy of retinoscopy.

Emmetropic and hyperopic eyes, in a state of rest, emit parallel and divergent rays, respectively, and to give such eyes a point of reversal, or a focus for the emergent rays, it will be necessary to intercept these rays with a convex lens as they leave the eye. In other words, emmetropic and hyperopic eyes must be made (artificially) myopic. In myopic eyes, however, the emergent rays always focus at some point inside of infinity, and the observer may, therefore, if he is so disposed, by moving his light and mirror to or from the patient's eye, as the case may be, find a point where the retinal illumination ceases to move. If this should be at two meters, the patient would have a myopia of 0.50 D.; if at four meters, a myopia of 0.25 D.; if at one meter, a myopia of one diopter, etc.

It is well for the beginner to remember, when using the plane mirror, that the illumination *on the patient's face always moves in the same direction the mirror is tilted*, but *not* necessarily so in the pupillary area, where it may appear to move opposite; and *here* it is that we speak of the retinal illumination moving with or against (opposite to) the movement of the mirror, as the case may be, and make our diagnosis accordingly.

As the rays of light from the mirror proceed divergently to the patient's eye, as if they came from a point back in the mirror equal to the distance of the light (opening in light-screen) in front of it and working at one meter's

distance, with source of light five inches in front of the mirror, the rays appear to emerge from a point five inches back of the mirror, or a total distance of 45 inches from the patient's eye, thus giving the rays of light a divergence equal to 0.87 of a diopter before they reach the patient's eye, and this point may be made conjugate to the retina. The observer will do good work if he reduces the retinal illumination to the utmost limit where it can be faintly seen moving with the movement of the mirror, and *if* this is done, the observer's eye and mirror will be just inside of the point of reversal where the erect image can still be recognized. In doing this, however, he must allow 0.87 in his estimate and not 1.00 D.

At the point of reversal no definite movement of the retinal illumination is made out and the pupillary area is seen to be uniformly illuminated, but not so brilliantly as when within or beyond the point of reversal.

If the observer's eye is, at this point, exactly conjugate to the retina, then the movement of the reflected light on the retina can not be perceived (though it does move), and the retinal illumination will occupy the entire pupil and the shadow will be absent.

Instead, however, of reducing the retinal illumination to the utmost limit (as just mentioned), where it can be faintly seen moving with the movement of the mirror, the writer prefers and recommends placing before the eye under examination such a lens or series of lenses as will bring the emergent rays of light to a focus on his own retina, so that no movement of the retinal illumination can be recognized.

When the point of reversal is approached, the uniform color of the retinal illumination occupies so much of the pupillary area that the student may think he has reached the point of reversal, and if he is not careful to pass the

retinal illumination slowly across the pupil and get the shadow, he will find his result deficient, and possibly miss seeing some small amount of astigmatism.

To make sure that the point of reversal has been obtained, it is always best, especially for the beginner, to keep putting on stronger neutralizing lenses until he gets a *reversal* of movement, when he knows at once that the point of focus of the emergent rays has passed in between the mirror and eye under examination.

The lenses which control the rays of light emerging from the patient's eye are spoken of as neutralizing lenses.

What to Avoid.—It occasionally happens that a retinal vessel or vessels or a remnant of a hyaloid artery, if present, or even the nerve head, may be seen when the light is reflected into the eye; if so, they are to be ignored, as they are not parts of the test. If the patient's eye is turned, or the rays from the mirror fall obliquely, or the neutralizing lens in front of the eye is inclined instead of being perpendicular, there will be seen reflections of light and images upon the neutralizing lens or cornea, or both, and, in consequence, the retinal illumination is more or less hidden or obscured; these images and reflections can be easily corrected by removing the cause. The catoptric images can not be removed, but as they are very small, the beginner soon learns to ignore them. The retinal illumination may occasionally contain a small dark center, which will disturb the beginner unless he remembers that it is caused by sight-hole in the mirror, and is likely to occur when the sight-hole is large and cut through the mirror. This same dark center in the illumination is also seen at times when the light is removed some distance from the mirror, and the correcting lens almost neutralizes the refraction. The neutralizing lens should never be so close to the eye that the lashes touch, and, in warm weather

especially, moisture from the patient's face may condense on the trial-lens, and temporarily, until it is removed, obscure the reflex.

Retinoscopy with a Plane Mirror at One Meter's Distance and Source of Light close to the Mirror.—Direction of Movement of Retinal Illumination.—Rate of Movement and Form of Illumination.—These important points in reference to the retinal illumination should be decided promptly and without any prolonged examination. This proficiency, of course, will only come by practice, and if, on first examination, the observer can not decide whether the retinal illumination is moving with or opposite to the movement of the reflected light on the face, he may approach the eye until this point is determined. At the distance of one meter the three important essentials may be stated in the following order and in the form of rules:

Direction of Movement of Retinal Illumination.—The recognition of the direction that the retinal illumination takes when tilting the mirror is a most important point in the study of retinoscopy.

The movement of the retinal illumination, when rotating the mirror, going *with* the movement of the light on the patient's face, signifies emmetropia, hyperopia, or myopia, if the myopia be *less* than one diopter.

The apparent movement of the retinal illumination going *opposite* to the movement of the light on the face always signifies myopia of *more* than one diopter.

Rate of Movement.—This, of course, is under the control and is influenced in great part by the rate of movement of the mirror itself; yet after a little practice the observer will recognize the fact that there is a certain slowness in the apparent rate of movement of the illumination when the refractive error is a high one and requires

a strong lens for its neutralization, whereas when the retinal illumination appears to move fast, the refractive error is but slight, and requires a weak lens for its correction.

Form of Illumination.—A large, round illumination, while it *may* signify hyperopia or myopia alone, yet it does not preclude astigmatism in combination.

When the illumination appears to move *faster* in one meridian than the meridian at right angles to it, astigmatism will be in the meridian of *slow* movement. If the retinal illumination is a band of light extending across the pupil, it signifies astigmatism.

The width of the band of light does not indicate so

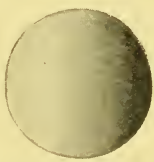

Fig. 16.—Straight Edge, Indicating Astigmatism.

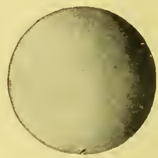

Fig. 17.—Crescent Edge, Indicating Spheric Correction.

much the strength of the correcting cylinder required for its neutralization as does the apparent rate of movement; if slow, a strong, if fast, a weak, cylinder is required.

The meridian subtended by the band of light that is seen when a spheric lens of one diopter or more corrects one meridian and the meridian at right angles remains partly corrected, indicates the axis of the cylinder in the prescription.

Rules for Placing Neutralizing Lenses.—A *plus* lens is required when the retinal illumination moves *with* the illumination on the face, and a *minus* lens is required when it moves *opposite* to the light on the face.

Movement of the Mirror.—There are times when a quick movement, and, at other times, a slow or gradual movement is required. A substitution of the quick for

the slow movement, and the result can not always be accurately determined. This is explained under "slow movement."

A quick movement of the mirror may be used when looking into the eye before any correcting lens has been placed *in situ*. It often tells the character of the refraction.

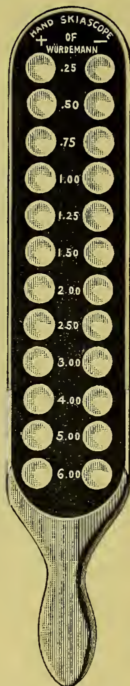

FIG. 18.—WÜRDEMANN'S DISC.

The slow movement of the mirror and the five-millimeter opening in light-screen come into use and are of the *utmost* importance when the eye has been corrected to within 0.75 D. or less, as it is generally at this point that so many, by a *quick* movement, hasten the peripheral rays and mask the central illumination, giving the idea at once of over-correction (see Spheric Aberration, chap. VI). This is a most common error with the beginner, the inexperienced, and with those who fail to get good results and who ridicule retinoscopy as "not exact," or as "not agreeing with the subjective method." It is well in *every* instance, when the point of reversal is approached, to pass the retinal illumination (not the light area on the face) well across the pupillary area to make *sure* in regard to the character of shadow which follows or precedes it. This movement, at such a point in neutralization, will often give a hint as to the presence of astigmatism or not, as a reference to Figures 13 and 14 will show. The presence of astigmatism is known by the straight edge of the illumination, or, in its place, a crescent edge would mean a spheric correction.

Apparatus for placing lenses in front of the patient's

eye.—There are several different forms in the market, their purpose being twofold—to save time and any extra movements on the part of the surgeon. Of these, that of Würdemann (*American Journal of Ophthalmology*, p. 223, 1891) seems the best hand skiascope. A reference to the sketch (Fig. 18) shows this instrument with its convenient handle, wherewith the patient, being instructed, raises or lowers

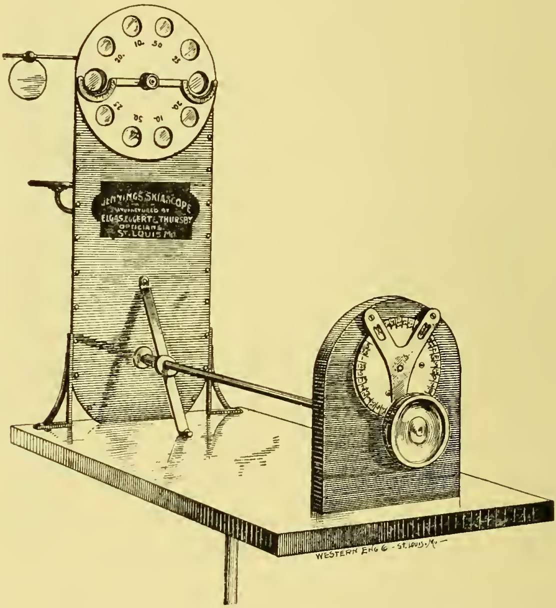

Fig. 19.—Jennings' Skiascopic Disc.

the disc in front of the eye, with its smooth broad edge resting against the side of the nose.

One column contains plus and the other minus lenses, and as it is reversible, these may be placed in front of the eye, as the surgeon directs.

The most modern and complete revolving skiascopic disc is that of Jennings (*American Journal of Ophthal-*

mology, November, 1896, and April, 1899), and may be best understood from his own description: "It consists of an upright metal frame, 18 inches high and 7 inches wide, placed at the end of a table 26½ inches long and 12 inches wide. In the upright frame is an endless groove containing 39 lenses and 1 open cell. At the lower end of the frame is a strong driving wheel connected with a horizontal rod running the length of the table to a handle with which the operator rotates the lenses. Facing the operator and close to his hand is a large disc, on which is indicated the strength of the lens presenting at the sight-hole. The

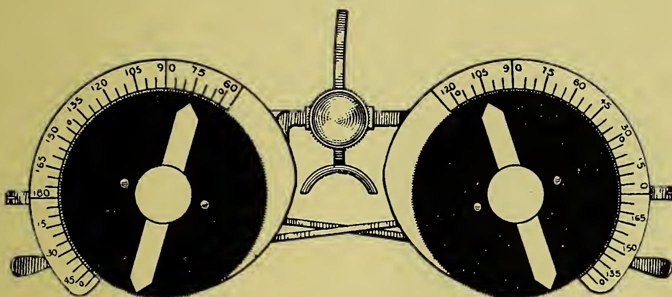

FIG. 20.—AUTHOR'S TRIAL-FRAME WITH AXONOMETERS ATTACHED.
(*Drawing reduced in size.*)

white numbers on a black ground represent convex, and the black numbers on the white ground concave, lenses. The lenses range from 0.25 D. to 9 D. plus, and from 0.25 D. to 9 D. minus. The sight-holes are ⅞ of an inch in diameter, and are placed about five inches from the top of the upright frame. In front of each sight-hole is a cell marked in degrees to hold stronger spheres or cylinders. The central portion of the upright is cut away, leaving a space for the face of the patient. A movable blinder is hung from the top, while the chin-rest moves up and down on two parallel rods and is held in place by a thumb-screw. The whole is mounted on a strong adjustable stand, which

is raised or lowered by means of a rack and pinion." The essential advantages of this skiascope are as follows:

1. It saves time and fatigue in changing lenses.

2. It is *under the immediate control of the operator,* and indicates the lens in front of the sight-hole without his getting up.

3. The mechanism is simple, durable, and easy to operate.

4. The cornea is accurately centered and the lens perpendicular to the front of the eye (a very important consideration, and one not possible with *every* kind of trial frame).

5. The instrument is of such length that the operator is always one meter distant from the patient.

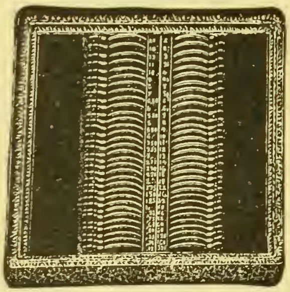

FIG. 21.—AUTHOR'S TRIAL-CASE FOR RETINOSCOPY.

While either the hand or the revolving disc is recommended, yet the writer is partial to an accurately fitting trial frame (Fig. 20), using the lenses from the trail-case, which should be conveniently at hand. The following suggestions in the selection and use of the trial-frame are offered: The temples should rest easily on the ears, the nose-piece (bridge) to have a sufficiently long post to permit the eye-pieces to fit high and accurately over any pair of eyes, especially those of children, and have the cornea occupy the center of each eye-piece. Correct results can not be expected or quickly obtained unless the neutralizing lenses be placed with their centers corresponding to corneal centers, and at the same time perpendicular to the front of the eye. A convenient and small trial-case containing a row of plus and minus spheres, from 0.12 to 10 D., is shown in Figure 21.

CHAPTER V.

RETINOSCOPY IN EMMETROPIA AND THE VARIOUS FORMS OF REGULAR AMETROPIA. —AXONOMETER.

Hyperopia.—In this form of refraction the direction of the movement of the retinal illumination is *with* the movement of the light on the patient's face. By rotating the mirror in the various meridians and observing the rate of movement, a strong or weak plus sphere, according to

FIG. 22.

FIG. 23.

FIG. 22.—GRAY REFLEX AS SEEN IN HIGH HYPEROPIA, EVEN DARKER THAN THE PICTURE SHOWS IT.

FIG. 23.—GRAY REFLEX, WITH CRESCENT EDGE BY TILTING MIRROR TO LEFT, DARKNESS OR SHADOW FOLLOWING.

the apparent rate of movement, is placed before the eye, and the rate of movement of the retinal illumination is again noted.

Practice alone will guide the observer in a quick appreciation of the approximate strength of neutralizing lens to thus employ.

If the movement of the illumination appears slow, and the observer places a +2.75 D. before the eye for its neutralization, and the illumination then becomes brilliant and appears to move fast and with the light on the face, the

hyperopia is still slightly uncorrected and a stronger lens must be substituted. (At this point in the examination the five-millimeter opening in the light-screen may be used to advantage.)

Removing the + 2.75 D. and substituting a + 3.25 D., if the retinal illumination is found to move *opposite* to the movement of the light on the face, the refraction of the eye will then be between the + 2.75 D. and the 3.25 D., which is 3 D. (See example, p. 24, chap. IV.) Now, while the + 3 D. has brought the emergent rays to a focus

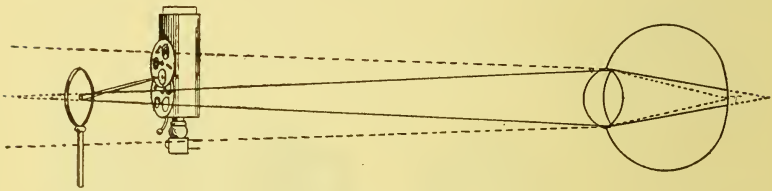

FIG. 24.

at one meter, it has made the eye myopic just one diopter, so that in taking the patient from the dark room to test his vision at six meters, or infinity, this one diopter (artificial myopia) must be subtracted from the + 3 D., which would leave + 2 D., the amount of the hyperopia.

A reference to Figures 24 and 25 will illustrate the description just given.

Figure 24 is the hyperopic eye under examination, and shows the mirror at one meter's distance, with the light five inches from the mirror. The dotted lines represent the rays proceeding divergently from the eye under examination; the dark lines show the reflected rays from the mirror, which illuminate the retina and have an imaginary focus (dotted lines) beyond the retina.

Figure 25 is a profile view showing the hyperopic eye

with neutralizing lens in position. The dotted lines with arrow-heads indicate the direction the rays would naturally take coming from the eye. The lens (+ 3 D.) in front of the eye is just sufficiently strong to bend these divergent rays and bring them to a focus at one meter's distance (artificial point of reversal). In other words, + 2 D. of the three diopters thus placed before this hyperopic eye would have bent the divergent rays and made them parallel, or emmetropic, but the additional one diopter bends the rays still more and brings them to a focus (P. R.) at one

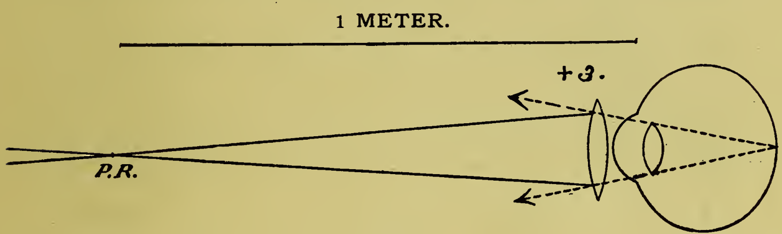

FIG. 25.

meter. If, now, the observer approaches the eye thus refracted and observes the retinal illumination closer than one meter, he will be inside of the point of reversal, and consequently see an erect image moving rapidly with the direction of the movement of the mirror. If beyond this point of reversal, he would get an inverted image and the retinal illumination moving rapidly in a direction opposite to the movement of the mirror.

Emmetropia.—The emergent rays from an emmetropic eye are always parallel, and the observer seated at one meter sees the pupillary area in such an eye brilliantly illuminated, the illumination moving rapidly with the light on the face as the mirror is slowly rotated.

A reference to Figure 26 shows the emmetropic eye under examination with the position of light, mirror, and

eye, as in Figure 24. The dotted lines indicate the parallel emergent rays, and the solid lines the divergent rays from the mirror with an imaginary focus just beyond the retina. The purpose in this instance, as in all others of retinoscopy, is to place such a neutralizing lens before the eye as will bend the emergent rays and bring them to a focus at a certain definite distance, making the emergent rays from a point on the retina come to a focus on the observer's retina. Therefore, to change this illumination so that no movement can be seen to take place in the pupillary area,

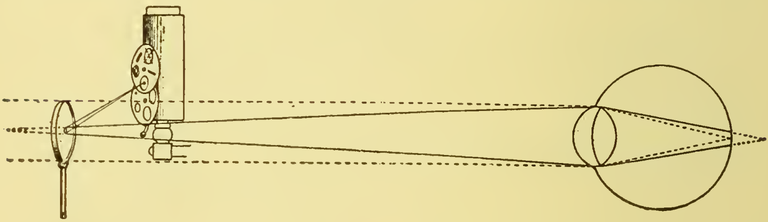

FIG. 26.

and at the same time have the emergent rays focus on the observer's retina, a + 1 sphere must be placed before the eye.

Just here the writer wishes to *impress* upon the beginner the great importance, as mentioned on page 14, of refracting the macular region. To accomplish this, the patient must fix his gaze upon the metal disc of the mirror. As the region of the macula is departed from, the strength of the neutralizing lens grows slightly stronger in emmetropia and hyperopia, and diminishes in myopia. A reference to Figure 27 will give an idea of what is meant, and show that radii drawn from the nodal point are not the same length as the one to the fovea.

Myopia.—In myopia the emergent rays *always* converge to the far-point (point of reversal), and the observer, seated

at one meter distant from the eye, will have the apparent movement of the retinal illumination going opposite to the light on the face *if* the myopia exceeds one diopter, and *with* the light on the face *if* the myopia is less than one diopter. If the myopia should be *just* one diopter, then the emergent rays would focus on the observer's retina at one meter, and there will not be any neutralizing lens required to accomplish this purpose; but if the emergent rays focus beyond one meter, the observer will be within this point of reversal or focus, and will, therefore, have an erect image, moving fast with the movement of the mirror, and will have to place before the eye a plus lens of less than one diopter to bring the point of reversal up to the distance of one meter. When the myopia is more than one diopter, and observer at one meter, the emergent rays will have focused somewhere between the observer and the patient, and, as a result, the retinal illumination appears to move opposite to the light upon the face, more or less rapidly, according to the amount of myopia; and a concave or minus lens must be placed in front of such an eye that will bring the emergent rays to a focus at one meter, or, in other words, will stop all apparent movement of the retinal illumination. If, for example, a – 2.75 D. has been so placed, and the movement is still slightly opposite to the movement of the mirror, and a – 3.25 D. substituted makes the retinal illumination move *with* the movement of the mirror, then the neutralizing lens for one meter will be between – 2.75 D. and – 3.25 D., which will be – 3 D.

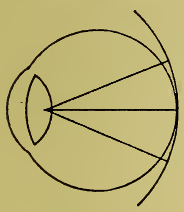

FIG. 27.

Figure 28 shows the myopic eye just described, with the position of the mirror, light, and eye as in Figures 24 and 26. The solid lines represent the rays reflected divergently from the mirror focusing at a point in the vitreous

before coming to the retina, and the broken lines show the rays emerging from a point on the retina and then converging to the focus, far-point, or point of reversal close to the eye, between the eye and the mirror. The observer, seated with the mirror one meter distant, gets an opposite movement in the pupillary area from the direction in which he moves his mirror, and of course, an inverted image. If the observer had his eye at the point where the emergent rays focused (dotted lines cross), he would not recognize any movement in the pupillary area, and it

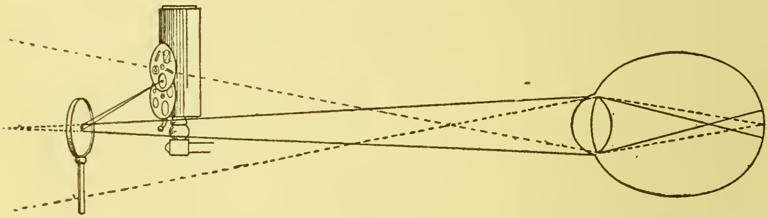

FIG. 28.

would have a uniform reflex. The amount of the myopia is equal to the distance measured from this point of reversal to the cornea; for example, if the distance (point of reversal) was twenty-five cm. from the patient's eye, then the amount of the myopia would be four diopters; if at 33 cm., then 3 D., etc.

Figure 29 is a profile view of the myopic eye. The dotted lines show the rays coming from a point on the retina and focusing at the far-point (F.P.); the solid lines show the emergent rays acted upon or bent by a plano-concave lens of three diopters, which has lessened the convergence of these emergent rays and put the far-point farther from the eye, or at a distance of one meter. The observer at this distance does not appreciate any movement in the pupillary area, but if he moves the light and mirror

closer to the eye he is then inside the point of reversal and gets an erect image moving with the movement of the mirror; if beyond the one meter's distance, an inverted image and movement against the movement of the mirror will be seen. If a − 4 D. lens had been placed before this myopic eye, the emergent rays would have proceeded from it parallel, and the observer, at one meter, would have the same conditions as in the refraction of an emmetropic eye, Figure 23; but as only a − 3 D. glass was used, the eye has one diopter of its myopia uncorrected. From

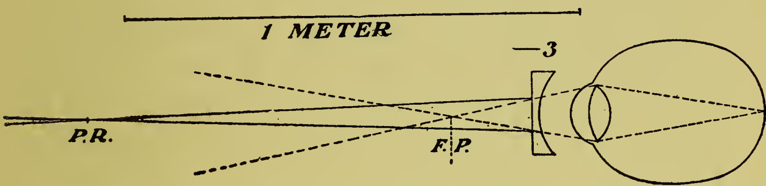

FIG. 29.

the description of retinoscopy in hyperopia, emmetropia, and myopia, just given, the student will recognize at once that the hyperopic, emmetropic, and myopic eyes of less than one diopter, working with the plane mirror at one meter's distance, are given a stronger refraction than they naturally call for, or, in other words, are made, artificially, myopic one diopter. And the myopic eye of more than one diopter, under similar conditions, being already myopic, retains one diopter of its myopia. To give a patient thus refracted with the retinoscope his emmetropic correction (correction for parallel rays of light), *an allowance must always be made, in all meridians, of one diopter, no matter what the refraction.* The artificial myopia thus produced at one meter gives the following rules for glasses required for infinity:

Rules.—1. When the neutralizing lens employed is plus, then subtract one diopter.

2. When the neutralizing lens employed is minus, then add a -1 D., or what is more simple, or even a better rule, is, To *always add a -1 sphere to the neutralizing lens obtained in the dark room when working at one meter, and the result will be the emmetropic or infinity correction.*

Examples:

DARK ROOM, ...	$+0.50$	0.00	$+1.00$	$+2.00$	-1.00
ADDING, ...	-1.00	-1.00	-1.00	-1.00	-1.00
EMMETROPIC CORRECTION,	-1.50	-1.00	-0.00	$+1.00$	-2.00

The main point in all retinoscopic work to remember in changing from the dark room to the six-meter correction, is to always allow for the distance from the patient's eye to the point of reversal—i.e., if working at half a meter, allow two diopters; if at two meters, 0.50 D.; if at four meters, 0.25 D., etc.

Regular Astigmatism.—When refracting with the retinoscope, the observer should remember *that he is refracting the meridian in the direction of which he moves the mirror.* Particular attention is called to this important fact on account of the confusion sometimes arising in the student's mind from the use of the ophthalmoscope, where the refractive condition of a certain meridian is estimated by the strength of the lens used to see clearly the vessels at right angles to it. Astigmatism being present in an eye, means a difference in the strength of the glass required for the two principal meridians, which, with few exceptions, are at right angles to each other, and it is to these two principal meridians *only* that the observer pays attention; for example, the eye that takes the following formula,

$$+1.00 \text{ D.} \bigcirc + 1.00 \text{ c. axis } 105^\circ,$$

means that in the 105 meridian there is $+1$ D. and in the

15 meridian a + 2 D. In the dark room a + 2 sphere in front of such an eye at one meter would correct the 105 meridian and partly correct the 15 meridian; or a + 3 D. would correct the 15 and over-correct (movement against) the 105 meridian. When with + 2 D, the 105 meridian is corrected and the 15 only partly so, there is seen in the 15 meridian a band of light which stands or extends across the pupil in the 105 meridian and moves across the pupil

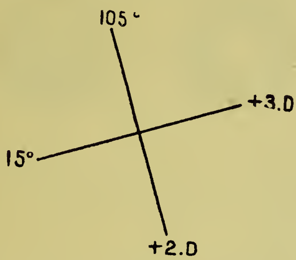

FIG. 30.

from left to right *with* the movement of the mirror as it is tilted in the 15 meridian.

The presence of this band of light *after* the meridian of least ametropia has been corrected *always* signifies astigmatism, and the axis it subtends—in this case 105° gives the axis of the cylinder in the prescription; and the amount of the astigmatism, or the strength of the cylinder required, is the difference between the strength of the two spheres employed. Figure 30 shows the method of writing such a dark room correction, and adding, according to our rule, a − 1 to this dark room work, we get our original formula:

$$+ 1.00 \text{ D.} \bigcirc + 1.00 \text{ c. axis } 105°.$$

The method of correcting with spheres (Fig. 21) will be found much more satisfactory than by placing a + 2 D., as called for in the 105 meridian, then adding and changing

cylinders until the correct one is found. It takes much time and care to get the cylinder axis just right, and is most difficult in the dark room. After the result has been obtained with spheres, the observer may, if he is so disposed, prove it before leaving the dark room with the sphero-cylinder combination.

Astigmatism may or may not be recognized on first

FIG. 31.

FIG. 32.

FIG. 31.—BAND OF LIGHT AT AXIS 60°, WITH THE 60° MERIDIAN NEUTRALIZED. No movement of the illumination can be recognized in the 60° meridian.

FIG. 32.—Shows the same as Figure 31, but the band of light with straight edge has been moved upward and to the left by tilting the mirror in the 150° meridian.

inspection of the fundus-reflex, this depending *entirely* on the refraction: if it be a high astigmatism with a small amount of refractive error in the opposite meridian, as in one of the following formulas,

$$+ 1.00 \text{ D.} \supset + 3.00 \text{ c. axis } 45°,$$
$$- 1.00 \text{ D.} \supset - 4.00 \text{ c. axis } 180°,$$

then the band of light so characteristic of astigmatism will be plainly seen on first inspection, extending across the pupil before any neutralizing lens has been placed in position; but if the hyperopia or myopia be high and the cylinder required is low, as in one of the following formulas,

$$+ 3.00 \text{ D.} \supset + 0.75 \text{ c. axis } 105°,$$
$$- 4.00 \text{ D.} \supset - 1.00 \text{ c. axis } 165°,$$

then the band of light is not recognized on first inspection or until an approximate correction has been placed before

the eye. To get an idea of what the band of light looks like, the beginner may refer to Figures 31 and 33; or focus rays of light through a strong cylinder; or place a cylinder in front of the schematic eye and study the retinal illumination. The student should bear in mind that the axis of the band of light appears on the meridian of least ametropia, and is brightest when this meridian has received its full spheric correction—the opposite meridian being only partly corrected.

The reason for the brightness of the band of light when the meridian of its axis is corrected is that any point on the retina in this meridian is conjugate to the focus on the observer's retina (point of reversal), and any movement of the mirror in this meridian is not recognized, but has a uniform color and occupies the entire meridian of the pupil. To recognize so small an error as a quarterdiopter cylinder—which is *not* easily detected, and the observer, if he is in a hurry, might think the case one of simple hyperopia or myopia—the writer would suggest that when the supposed point of reversal is reached the correcting sphere be increased a quarter of a diopter, and *if* only one meridian is found over-corrected (movement opposite), the other remaining correct (no movement recognized), he *then* knows that a quarter cylinder is required; for example, a + 2 D. is supposed to correct all meridians, and yet by substituting a + 2.25 D., the vertical meridian moves against and the horizontal remains stationary; then a + 0.25 D. cylinder is called for at axis 90°.

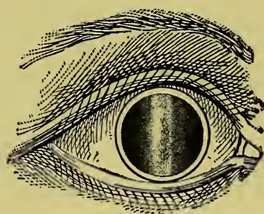

FIG. 33.—BAND OF LIGHT ASTIGMATISM AXIS 90°.

Cases having a low astigmatic error of 0.50 D. can be recognized when near the point of reversal by the faint

shaded area on each side of the band of light, as shown in Figure 34—a condition often overlooked.

Mixed Astigmatism.—In this condition of refraction, where one meridian is myopic and the meridian at right angles to it is hyperopic, the movement of the retinal illumination in the myopic meridian will be controlled by the *amount* of the myopia. The illumination in the myopic

FIG. 34.—BAND OF LIGHT SHOWING HALF A DIOPTER OF ASTIGMATISM.

meridian, if the myopia is less than one diopter, moves *with* the mirror, and against the movement of the mirror if it is more than one diopter; in either instance the observer gets a distinct band of light in the meridians alternately as each meridian is neutralized separately with a sphere. Taking the following example,

$$-2.00 \text{ c. axis } 180^\circ \bigcirc + 1.00 \text{ c. axis } 90^\circ,$$

the 90 meridian shows an *opposite* movement, and in the horizontal the movement is *with* the movement of the mirror. If, now, a -1 D. sphere be placed before the eye, the 90 meridian is neutralized for one meter distance, and a bright band of light is seen at 90°, moving with the movement of the mirror in the horizontal meridian. Removing the -1 D. and placing a $+2$ D. before the eye, which would neutralize the horizontal meridian for one meter, a bright band will be seen in the horizontal meridian and moving opposite to the movement of the mirror in the 90° meridian. Carrying out the rule of always adding a -1 D. sphere to the correction obtained in the dark room at one meter, we have -1 added to the -1 in the vertical meridian, making

−2 D., in axis 180°; and adding −1 to the +2 D. in the horizontal, we have +1 D. in axis 90°, or our original formula.

$$-2.00 \text{ cyl axis } 180^\circ \supset +1.00 \text{ c. axis } 90^\circ.$$

The rule for neutralizing lenses in mixed astigmatism is the same as for any other form of refraction; namely, using a plus lens when the movement is with, and a minus lens when the movement is opposite to, the movement of the light on the face.

To transpose crossed cylinders into a sphero-cylinder combination the writer would advise using the rule of Dr. Harry S. Pearse, of Albany, which is as follows:

"The cylinder is the sum of the two cylinders with the sign and axis of one of the cylinders. The sphere is the strength of the other cylinder with its sign." In the above formula, the sphero-cylinder combination will be

$$-2 \text{ D.} \supset +3.00 \text{ c. axis } 90^\circ.$$

Axonometer.—To find the exact axis subtended by the band of light while studying the retinal illumination, when the meridian of least ametropia has been corrected, the writer has suggested a small instrument, which, for want of a better name, he has called an axonometer.

Figure 35 shows this instrument, and Figure 36 the axonometer in position.

The original description of this device was published in *The Medical News*, March 3, 1894, as follows: "The direction of the principal meridians of corneal curvature is often difficult to determine, and the statement of the patient must be accepted when confirming the shadow-test correction; or, if there is still uncertainty, the ophthalmometer of Javal may be of service. The axonometer is a black metal disc, with a milled edge, one and one-half mm. in thickness, of the diameter of the ordinary trial-

lens, and mounted in a cell of the trial-set. It has a central round opening 12 mm. in diameter—the diameter of the average cornea at its base. Two heavy white lines, one on

FIG. 35.

each side, pass from the circumference across to the central opening, bisecting the disc. To use the axonometer, place it in the front opening of the trial-frame, and with the patient seated erect and frame accurately adjusted so that

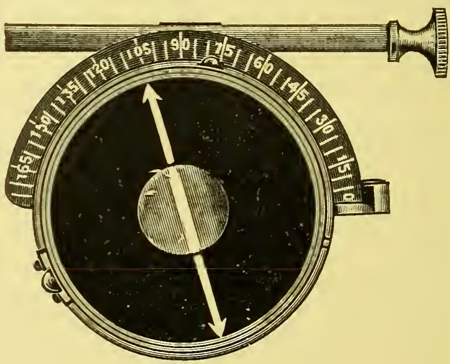

FIG. 36.

the cornea of the eye to be refracted occupies the central opening, proceed as in the usual method of making the shadow test. As soon as that lens is found which corrects

the meridian of least ametropia, and the band of light appears distinct, turn the axonometer slowly until the two heavy white lines accurately coincide, or appear to make one continuous line with the band of light (see Fig. 33).

"The degree marks on the trial-frame to which the arrow-head at the end of the white lines then points is the exact axis for the cylinder. The axonometer possesses the following points of merit:

"Simplicity.

"Accuracy.

"Small expense.

"It covers an unnecessary part of the trial-lens which too frequently gives annoying reflexes and images.

FIG. 37.

"It saves time, avoids the statement of the patient, and renders the ophthalmometer unnecessary.

"Its color (black) absorbs the superfluous light rays from the mirror and gives a stronger contrast to the reflex and central illumination.

"Limiting the field of vision in children, it permits of more concentrated attention.

"For children and nervous patients, when it is difficult to use the ophthalmometer, this simple appliance is of great service."

Lately the writer has improved the axonometer by having the white lines broadened to four millimeters, which is a decided advantage over the instrument shown in Figures 35 and 36 as the broad line is easily seen at one meter distance. This axonometer, shown in Figure 37, is made of thick celluloid.

CHAPTER VI.

RETINOSCOPY IN THE VARIOUS FORMS OF IRREGULAR AMETROPIA.—RETINOSCOPY WITHOUT A CYCLOPLEGIC.—THE CONCAVE MIRROR.—DESCRIPTION OF THE AUTHOR'S SCHEMATIC EYE AND LIGHT-SCREEN.—LENSES FOR THE STUDY OF THE SCISSOR MOVEMENT, CONIC CORNEA, AND SPHERIC ABERRATION.

Irregular Astigmatism.—This condition is either in the cornea or in the lens, or in both structures in one and the same eye; in any instance it is confusing to the beginner, and even the expert must work slowly to obtain a definite result. The corneal form is most difficult to refract as the retinal illumination is more or less obscured by areas of darkness. The illumination between these dark areas appears to move with, in places, and in others against, the movement of the mirror. By moving the mirror so as to make the light describe a circle around the pupillary edge, a most unique kaleidoscopic picture is obtained, which is quite diagnostic of the condition. To refract an eye with this irregularity the observer may have to change his position several times, going closer to or farther away from the patient. Very often these eyes are astigmatic, and the band of light may be promptly noted by the observer changing his position as suggested, and at the same time placing a neutralizing lens in position. Care *must* be taken, also, to refract in the area of the cornea that will correspond to the small pupil when the effect of the cycloplegic passes away. It is often best, in these cases of

irregular corneal astigmatism, to make a record of the correction found and use it as a guide in a post-cycloplegic manifest refraction.

Irregular astigmatism of the lens is frequently more or less uniform, and not so broken as in the corneal variety. Figures 38 and 39 show two kinds of irregular lenticular astigmatism.

Figure 35 illustrates the spicules pointing in from the periphery, and so long as these do not encroach upon the pupillary area, they do not usually in themselves interfere

FIG. 38. FIG. 39.
IRREGULAR LENTICULAR ASTIGMATISM.

with vision; they are not often recognized until the pupil is dilated, are then very faint, and not usually made out until the point of reversal is approached. Figure 39 is another form of irregular astigmatism, and a very interesting picture as studied with the retinoscope; and, as in Figure 38, *when* very faint, is not made out until close to the point of reversal. These two forms of irregular lenticular astigmatism, when *just* beginning, are very seldom seen with the ophthalmoscope; the striations are too fine to be made out except under the conditions just described, and when recognized are of inestimable value from a point of prophylactic treatment, calling for a change of occupation, rest to the eyes, and carefully selected glasses, the latter often being weak lenses. These lenticular conditions not infrequently accompany the "flannel-red" fundus, the "fluffy eye ground," the "shot-silk retina," the "woolly choroid," etc.

Scissor Movement.—Another form of astigmatism that may be classed as irregular is where there are two areas of light, each with a straight edge, and usually seen on the horizontal meridian, or inclined a few degrees therefrom either way, and moving toward each other as the mirror is tilted in the opposite meridian; in other words as the observer is seated at one meter he sees an area of light above and an area of light below with a dark interspace (Fig. 40). As the mirror is slowly tilted in the vert-

FIG. 41.—LIGHT AREAS COMING TOGETHER AND DARK INTERSPACE FADING.

ical meridian these light areas approach and are followed by darkness or shadow, and at the same time the dark interspace begins to fade, giving the picture as shown in Figure 41. When the light areas are brought together, they result in a horizontal band of light, as seen in Figure 42, and at this point resemble the ordinary band of light as seen in regular astigmatism. This movement of the light areas is likened to the opening and closing of the scissor blades, and hence the name of scissor movement.

These cases are more or less difficult to refract, but the presence of the two areas of light with the dark interspace will often assist in a correct selection of glasses, for while they are generally of the compound hyperopic variety, calling for a plus sphere and plus cylinder, yet practice and the patient's statement often call for a plus sphere and minus cylinder.

With the following formula,

$$+ 2.00 \text{ D.} \bigcirc + 0.75 \text{ c. axis } 90^\circ,$$

substituting a sphere the strength of the combined values of the sphere and cylinder, and using a minus cylinder of the same number as the plus cylinder at the opposite axis, the result will be,

$$+ 2.75 \text{ D.} \bigcirc - 0.75 \text{ c. axis } 180^\circ.$$

The vision with the latter formula is much better in many instances than with the former, and though either formula would be correct, yet the latter is practically the

FIG. 40.

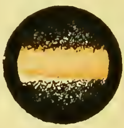

FIG. 42.

FIG. 40.—LIGHT AREA ABOVE AND BELOW, WITH DARK INTERSPACE.
FIG. 42.—LIGHT AREAS BROUGHT TOGETHER.

better of the two, and should be ordered when so found. The writer's method of procedure when he recognizes the scissor movement is to tilt the mirror until the two light areas are brought into one band of light as shown in Fig. 42 and then to reflect the light through the meridian of this band (in this instance as illustrated, the 180 meridian). Having obtained the lens which neutralizes the movement in this meridian, the writer does not attempt to find the neutralizing lens for the opposite meridian but goes from the dark room to the trial-case and places before the patient's eye that sphere which corrects the refraction in the horizontal meridian. For instance, if + 3.75 D. corrects the horizontal meridian at one meter, then + 2.75 D. sphere is placed before the eye, and a minus cylinder (beginning with − 0.50. at axis 180 degrees) is placed in front of the sphere and the strength of this minus cylinder is gradually

increased so long as the visual acuity improves. In other words the writer does not attempt to estimate the refraction with the retinoscope in the meridian opposite to the bands of light. The condition which may be the probable cause of the scissor movement is a slight tilting of the lens (see Fig. 43)—that is, the antero-posterior axis of the lens does not stand perpendicular to the plane of the cornea, thus making one portion of the pupil myopic (area of light moving opposite) and the other portion hyperopic (area of light moving with the movement of the mirror). This condition may be simulated by placing a convex lens at an angle before the schematic eye, or reflecting the light into the eye obliquely, or by using the combination lens in front of the schematic eye, as suggested on page 61.

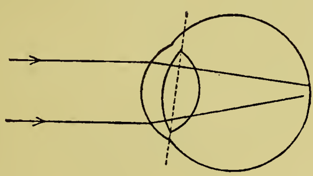

FIG. 43.

What causes the tilting of the lens the writer is not prepared to state *positively;* it may be congenital, and yet careful inquiry of the patients, in many instances, has shown that it is most likely due to using the eyes to excess in the recumbent posture. It may be a coincidence, but most of the cases of scissor movement seen by the author have been in adults, and those who were in the habit of reading while lying down, reading themselves to sleep at night in bed.* Other cases were seen among paper-hangers, whose occupation compelled them to look upward much

*The writer does not wish to be misunderstood and does *not* say that every one who uses his eyes in this faulty position *must* develop this form of irregular astigmatism.

of the time. These do not seem unlikely causes, especially when the anatomy of the ciliary region is considered, the strain of the accommodation (possibly spasm) during the faulty position of the eye tilting the lens as it rests upon the vitreous body. This form of astigmatism, so far as known, remains a permanent one even after a cessation from the original cause and correcting glasses have been ordered. The retinoscope is the only instrument of precision we have in diagnosing this condition. The ophthalmoscope may

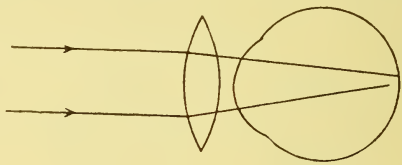

FIG. 44.

recognize the presence of the astigmatism, but not its character, and the ophthalmometer only records the corneal curvature. Cases of aphakia (following cataract *extraction*) frequently show the scissor movement *during* the process of retinoscopy. This is undoubtedly due to the flattening of the cornea corresponding to the section, making one portion myopic and the other hyperopic. Figure 44 with correcting sphere in position, shows such a condition, where the upper illumination would move with and the lower, being myopic, would move against the movement of the mirror.

Compound Irregular Astigmatism.—This is a combination of the scissor movement and regular astigmatism, but they are *not* at right angles to each other. The scissor movement may be at 180°, and the regular astigmatism at some point *away* from 90°, but not at 90°; or the regular astigmatism may be at 90° and the scissor movement at some meridian other than 180°.

A hasty review of the literature of astigmatism does not reveal any reference to this form, and the name for the condition has been suggested by the following picture, namely: When studying the reflex, a vertical band of light will be seen passing across the pupillary area from left to right as the mirror is turned, and then in the vertical meridian (*not* at right angles) the scissor movement will be recognized also; there is, therefore, a combination of regular corneal astigmatism with the scissor movement at an oblique angle, giving the compound name suggested. This form of astigmatism is rare, yet not difficult to diagnose or refract when understood. It is hoped, however, that the beginner in retinoscopy may not meet one of these on his first attempt at the human eye. (See page 63).

Conic Cornea.—Reflecting the light into an eye that has such a condition, the observer is impressed at once

FIG. 45.—ILLUMINATION SEEN IN CONIC CORNEA.

with the bright central illumination that moves opposite to the movement of the mirror, the peripheral illumination moving with, unless perchance the margin should be myopic also, but of less degree. This form of illumination is seen in Figure 45, showing the central illumination faintly separated by a shaded area or ring from the peripheral circle. The best way to refract a case of this kind is to keep a record of the neutralizing lens or lenses required for the portion of the pupillary area that will correspond to the size of the pupil after the effect of the cycloplegic passes away, and use this record as a guide in a post-cyclo-

plegic manifest correction, as in irregular corneal astigmatism.

As the apex of the cone is not always central, the observer must not expect to always find the bright illumination in the center of the pupillary area, as just mentioned; and it is also well to note the fact that a band of light will often appear during the process of neutralization, as astigmatism is usually present. This is further described on page 62.

Spheric Aberration.—This appears under two forms, positive or negative, and is the condition in which, during

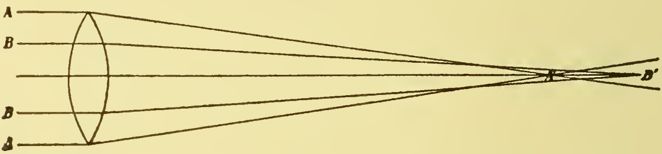

FIG. 46.—POSITIVE ABERRATION.

the process of neutralization, there are two zones, one central and the other peripheral, where the refraction is not the same. In positive aberration the peripheral refraction is stronger and in negative aberration the peripheral

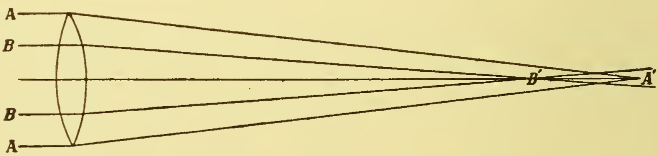

FIG. 47.—NEGATIVE ABERRATION.

is weaker than the central area; that is to say, in the positive form, when the point of reversal for the center of the pupil is close to one meter, the peripheral illumination grows broader and has a tendency to, and often will, crowd in upon the small central illumination, giving the idea of

neutralization, or even the appearance of over-correction, the illumination in the periphery moving opposite. The observer must be on his guard for this condition, and while giving the mirror a slow and limited rotation must watch carefully the illumination in the center of the pupil and *not* hasten the peripheral movement. (See What to Avoid, p. 26, chap. IV.) The observer may have to approach the patient's eye closer than one meter if the peripheral illumination appears to move very fast. The negative form is where the peripheral refraction is weak as compared to the central which appears strong, and when the neutralizing lens gives a point of reversal at the center of the pupil the peripheral illumination still moves with the movement of the mirror. This condition is seen in cases of conic cornea.

Figure 46 illustrates positive aberration where the parallel rays passing through a convex lens in the periphery at A A come to a focus at A', much sooner than the parallel rays B B, near the center, which comes to a focus back of A' at B'.

Figure 47 illustrates negative aberration, which is the reverse of positive aberration, and the central rays B B are focused at B' in front of the peripheral rays A A focusing at A'.

Retinoscopy Without a Cycloplegic.—Cases of myopia and mixed astigmatism which have large pupils *can* be quickly and accurately refracted by the shadow test without the use of a cycloplegic. This has been repeatedly proven by comparison of the manifest and cycloplegic results; yet it is not a method to be recommended or pursued, for two reasons: One is that these patients are not annoyed, like hyperopics, by the blurred near-vision incident to the cycloplegic; and, secondly, glasses ordered without the cycloplegic seldom give the comfort that follows from the

physiologic rest the eye receives from the drug. The surgeon will obtain much assistance and save time by using the retinoscope in cases of aphakia, in old persons especially who are very slow to answer, and will insist upon a description of what they do and do not see, as also in re-reading the test-card from the very top each time a change of lens is put in the trial-frame. Presbyopes of fifty or more years of age can be quickly and not inconveniently refracted by the shadow test after having their pupils dilated with a weak (four per cent.) solution of cocain.

Concave Mirror.—While the study of retinoscopy with the concave mirror is not a part of the subject of this book, and allusion to it has been carefully avoided up to this time, yet for the benefit of those who may wish to try it, the writer would suggest that it will be necessary to place the source of light (20 or 30 mm. opening in light-screen) above and beyond the patient's head, one meter distant, or more, so that the convergent rays from the mirror come to a focus and cross before entering the observed eye. Then to estimate the refraction, proceed as with the plane mirror, remembering, however, that the movements of the retinal illumination are just the reverse of those obtained when using the plane mirror.

The Author's Schematic Eye for Studying Retinoscopy.—For illustration see Figure 1 and the *Journal of the American Medical Association*, January 5, 1895. The eye is here shown, slightly reduced in size, is made of two brass cylinders, one somewhat smaller than its fellow, to permit slipping evenly into the other. Both cylinders are well blackened outside. The smaller cylinder is closed at one end (concave surface), and on its inner surface is placed a colored lithograph of the normal eye ground. The larger cylinder is also closed at one end, except for a central round opening 10 mm. in diameter, which is occupied

by a + 16 D. lens, and on its outer surface is a colored lithograph of the normal eye and its appendages; the pupil is left dilated, and corresponds in size to the central opening just referred to. In addition to the picture of the eye, there is also lithographed on the upper half of the periphery the degree marks similar to those on a trial-frame. To the lower half of the periphery are secured, at equal distances, three posts with grooves to hold trial-lenses. On the side of the small cylinder is an index which records emmetropia, and the amount of myopia and hyperopia, as it is pushed into or drawn out of the large cylinder. The eye is mounted on a convenient stand and upright, so that it may be moved as required. In using this eye, if the red eye ground and retinal vessels disturb the beginner, then he may substitute a piece of white paper for the retina. To study astigmatism with the model, the beginner will have to place a cylinder of known strength in the groove next to the eye and study the characteristic band of light so diagnostic of this condition, and at the same time he should learn to locate the axis of the band with the axonometer.

The author's light-screen or cover chimney (see Figure 5 and the *Annals of Ophthalmology and Otology*, October, 1896) is made of one-eighth inch asbestos, and of sufficient size to fit easily over the glass chimney of the Argand burner; attached to the asbestos by means of a metal clamp are two superimposed discs, which revolve independently of each other The lower disc contains a piece of white porcelain, 30 mm. in diameter; also four round openings, respectively 5, 10, 20, and 35 mm. in diameter. The upper disc contains a round 35 mm. opening, a round section of blue cobalt glass, a perforated disc, a vertical and a horizontal slit, each 2½ by 25 mm. The several uses of this screen are as follows:

1. For the ophthalmoscope a good light is obtained by superimposing the two 35 mm. openings.

2. Combining the 35 mm. opening in the upper with either the 5 or 10 mm. in the lower disc, a source of light is produced for the small retinoscope; and,

3. By substituting the 20 mm. opening, light is had for the concave mirror.

4. Placing the cobalt glass over the 5, 10, 20, or 35 mm. opening, and the chromo-aberration test for ametropia is given.

5. To test for astigmatism at one meter while using the plane mirror, or for heterophoria at six meters, the perforated disc is to be turned over the porcelain, the latter producing a clear white image.

6. The horizontal slit placed over the porcelain glass, and the operator may exercise the oblique muscles.

7. The vertical slit similarly placed gives the test for paralyzed muscles.

Lenses for the Study of the Scissor Movement, Conic Cornea, Spheric Aberration, and Lenticular Astigmatism.—(Described by the author in the *Journal of the American Medical Association*, December 18, 1897.)

As the scissor movement, conic cornea, spheric aberration, and lenticular astigmatism, as recognized by the retinoscope, are so difficult of demonstration, except in the individual patient, the writer has suggested and had made four lenses which will illustrate these conditions respectively when placed in front of his schematic eye; and thus the beginner in retinoscopy may have the opportunity to see, know, and study these important and interesting manifestations (and at small expense) before proceeding direct and in comparative ignorance to his patient.

Figures 48 and 49 represent a plano-concave cylinder of two diopters, mounted in a cell of the trial-case, and to

one-half of its plane surface is cemented (at the same axis) a plano-convex cylinder of four diopters, thus making a combination lens, one-half of which is a -2 D. and the other half equaling a $+2$ D. Placing this lens, with its axis at 180°, before the schematic eye at emmetropia (zero), and the observer at one meter distance with his plane mirror, the two light areas characteristic of the scissor

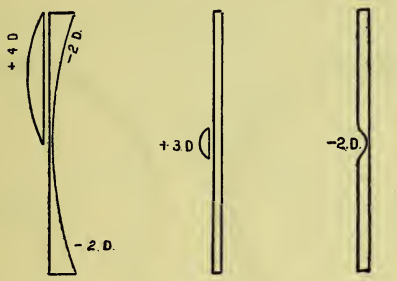

FIG. 48. FIG. 50. FIG. 52.

movement, with their comparatively straight edges and dark interspace may be seen approaching each other from above and below (and the dark interspace disappearing) as the mirror is tilted in the vertical meridian.

Figures 50 and 51 represent a section of thin plane glass mounted as in Figure 48 and has cemented at its center a small plano-convex sphere of three diopters, whose base is about four mm. in diameter. Placing this lens in front of the schematic eye at emmetropia, and reflecting the light from the plane mirror at one meter, there will be seen in the pupillary area a small central illumination, which moves against or opposite to the movement of the mirror, and at the same time there will also be seen a peripheral ring (at the edge of the iris) which moves rapidly with the movement of the mirror; between these light areas is a shaded ring of feeble illumination. This is the retino-

scopic picture and movement of the light areas, so indicative of conic cornea. It is also an exaggerated picture of negative aberration.

Figures 52 and 53 represent a section similar to that shown in Figures 50 and 51, except that at its center is ground a -2 D. sphere of about four mm. in diameter. To produce spheric aberration of the positive form, place this lens in front of the schematic eye at emmetropia, and the observer, seated at one meter distance with the plane

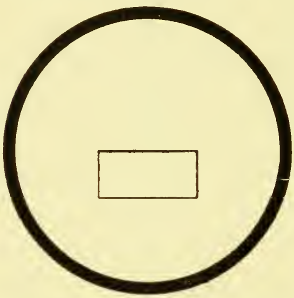

FIG. 49.

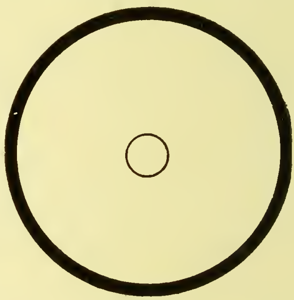

FIG. 51.

mirror, will see in the pupillary area a central illumination which moves slower than the peripheral area or ring (at the edge of the iris), which moves rapidly, both areas moving with the movement of the mirror. Figure 54 shows a lens for studying lenticular astigmatism. This is made by scratching a piece of plane glass with a diamond.

After the observer has carefully studied these pictures, it will be obvious that changes other than those mentioned can be made with these lenses, and he should proceed to note them by—

1. Changing the focus of the schematic eye.
2. By varying his distance from the eye.
3. By placing both the concave and convex spheres in combination.

4. By placing a concave cylinder in front of the double cylinder at an oblique axis, thus getting a picture of compound irregular astigmatism.

5. By placing a concave cylinder in front of the convex sphere and developing astigmatism with the conic cornea,

FIG. 53.

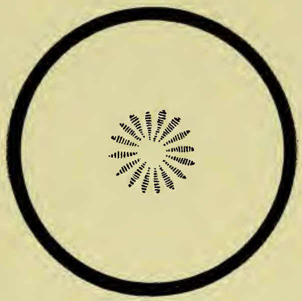

FIG. 54.

which is the usual condition; or a convex cylinder might be used in place of the concave cylinder if a higher error is desired.

6. It is obvious, also, that the scissor movement can be produced by a prism which is made to cover one-half of the pupillary area, but the resulting picture is not so satisfactory for demonstration as that given by the combination lens referred to in Figure 48.

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